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Project Landsat C

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For Release:

Dick McCormack
Headquarters, Washington, D.C.
(Phone: 202/755-8583)

IMMEDIATE

Don Witten
Goddard Space Flight Center, Greenbelt, Md.
(Phone: 301/982-4955)

RELEASE NO: 78-22

IMPROVED LANDSAT TO GIVE BETTER VIEW OF EARTH RESOURCES

NASA will launch a new, improved satellite to monitor the Earth's resources -- Landsat C -- from the Western Test Range near Lompoc, Calif., on March 5.

Landsat C is the third in a series of satellites designed to orbit the Earth at an altitude of 917 kilometers (570 miles) and scan our planet's surface in a systematic study of its resources and environment. The spacecraft will be designated Landsat 3 after achieving successful orbit.

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The 900-kg (1,980-lb.) Landsat 3 will be placed into a 917-km (570 mi.) circular, near polar orbit. Circling the globe every 103 minutes, the spacecraft's remote sensors will view a 185-km (115-mi.) wide strip of the Earth running nearly north-to-south at an angle to the equator of 99 degrees.

In this type of orbit, surface coverage of the Earth will proceed westward, with a slight overlap, such that the globe will be covered once every 18 days. The spacecraft's orbit is synchronous with the Sun. Thus Landsat 3 (like Landsat 2) will cross the equator at the same time (9:30 a.m. local time) every orbit. This results in consistent and constant lighting of Earth, the best condition for the spacecraft's imaging systems.

Synoptic, repetitive coverage of Earth's surface under consistent observation conditions is required for maximum utility of the multispectral imagery to be collected by Landsat 3.

The most common value attributed to the Landsat system is the large-scale perspective. Structural elements, perhaps irregular or even discontinuous within the confines of a smaller area, may be revealed as regional or even semi-continental in extent.

Another major asset of the Landsat system is its repetitive observation which makes possible the detection of short-period changes -- as frequently as every nine days using two satellites.

The three most important potential uses of the Landsat data identified so far correspond to three of the major problems confronting the world today. These are energy supplies, food production and global large-scale environmental monitoring.

Innovations in the Landsat 3 multispectral scanner system (MSS) will provide for the detection of temperature differences in vegetation, bodies of water and urban areas -- day or night.

Improvements in the return beam vidicon (RBV) sensor will increase the resolution of its recorded images by 50 per cent. Thus, areas as small as half an acre -- about two urban house lots -- can be identified and studied.

In addition to its two major remote sensing systems, the Landsat 3 carries a data collection system (DCS). This versatile experiment collects radioed data directly from as many as 1,000 remote ground platforms and relays them to a Landsat data acquisition station.

Volcano activity, stream flow, water and snow depth, water temperature and sediment density are some of the measurements collected with the DCS.

Landsat 3 will be launched from the Western Test Range (WTR) aboard a two-stage Delta launch vehicle. In addition to Landsat 3, riding piggyback aboard the rocket will be an amateur radio communications satellite -- the OSCAR-D. This satellite will be used by amateur radio buffs around the globe for a variety of uses, particularly with small fixed and mobile stations. Primary emphasis will be placed on its application as a teaching aid in secondary schools.

Another experiment attached to the second stage of the expendable Delta rocket will be a unit to help designers of future space systems. This unit, called the Plasma Interaction Experiment (PIX), will remain in orbit at an altitude lower than either the Landsat 3 or the OSCAR-D. It is designed to provide information on how to control detrimental interactions between high voltage systems and the electrically charged plasma fields in space.

The Landsat sensors are improved versions of the MSS and the RBV units carried by the two earlier Landsats. All three satellites carry the same DCS experiment.

The improved sensors on Landsat 3 are expected to supply data significantly improved over those used in the proven applications of Landsats 1 and 2. In agriculture, for instance, the added thermal infrared channel on the MSS is expected to be the major improvement. The thermal data should provide information on plant stress, vigor and other changes characterized by temperature differences. The improved resolution RBV system should provide more accurate measurements of agricultural fields to improve the crop yield projection.

NASA's research program is being geared to assess the value of these improved data sources as well as to incorporate their information content in the current operational applications of Landsat data by other federal, state and industrial users.

The improved Landsat 3 data will provide more accurate discrimination between suburban areas and surrounding rural or farm lands (important for census studies); will increase our ability to recognize "heat islands" associated with urban and industrial developments; and will permit improved monitoring of thermal sources such as mine fires and power plant effluents.

Three NASA tracking and data acquisition facilities are equipped to receive sensor data from the Landsat spacecraft. The Landsat facilities at Goldstone, Calif., and at Goddard Space Flight Center, Greenbelt, Md., can receive sensor and DCS data directly from the spacecraft whenever it is in direct line-of-sight. The primary station at Fairbanks, Alaska, collects such data by commanding the satellite's tape recorders to replay during each orbit over the North Pole area.

International interest in Earth resources remote sensing is widespread and growing. Foreign-funded ground stations are now operating in Brazil, Italy and Canada (two facilities). Another station is under construction in Iran and others are being planned by Argentina, Chile, India and Zaire. Australia, Japan and Sweden are among other countries presently considering such an investment.

Landsat ground stations cost the host country some \$4 to \$7 million to establish and from \$1 to \$2 million per year to operate. In addition, countries operating these stations are paying the U.S. \$200,000 per station a year as of July 1976. This charge was established by NASA to assist in defraying the cost for the space segment. Data from foreign stations is distributed directly by the organizations operating the stations.

Once Landsat data received in the U.S. is processed at Goddard Center, copies will be forwarded to the Department of Interior's Earth Resources Observation Systems (EROS) Data Center at Sioux Falls, S.D. On receipt at Sioux Falls, data are in the public domain and copies can be purchased by anyone.

The overall Landsat program is the responsibility of NASA's Office of Space and Terrestrial Applications, Washington, D.C.

Project management for the Landsat spacecraft, the Delta launch vehicle, the NASA Image Processing Facility and the worldwide tracking network rests with the Goddard Center.

Launching of the Delta is supervised by the Kennedy Space Center's unmanned launch operations team.

General Electric Co., Space Division, Valley Forge, Pa., is the prime contractor for the Landsat spacecraft, the data collection system and wideband video tape recorders aboard the spacecraft and the ground data handling system at Goddard.

Hughes Aircraft Co., Space and Communications Group, El Segundo, Calif., is prime contractor for the multispectral scanner; and RCA, Astro-Electronics, Princeton, N.J., is prime contractor for the return beam vidicon camera. The McDonnell Douglas Astronautics Co., Huntington Beach, Calif., is prime contractor for the Delta launch vehicle.

NASA costs for the Landsat program are about \$251 million. This includes \$149 million for three spacecraft and their instruments, \$54 million for the data handling facility at Goddard Center and ground operations, \$34 million for support of investigations and about \$14 million for three launch vehicles.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

THE SPACECRAFT

Design of Landsat 3 is similar but features many improvements over the two Landsat spacecraft now in orbit. All of these satellites are patterned after the successful Nimbus research spacecraft which has returned valuable data on the Earth's dynamic meteorological systems since 1964.

The Landsat 3 is equipped with sophisticated systems providing solar power, thermal control and three-axis stabilization. It is designed to be a stable, Earth-oriented platform -- features required for high-resolution remote sensing from space.

The spacecraft's design lifetime is one year. It carries two different experimental systems for remotely sensing features on the Earth's surface and another system for collecting data directly from beacon platforms in remote areas. Two onboard video tape recorders store data for playback when the spacecraft is out of sight of a ground station.

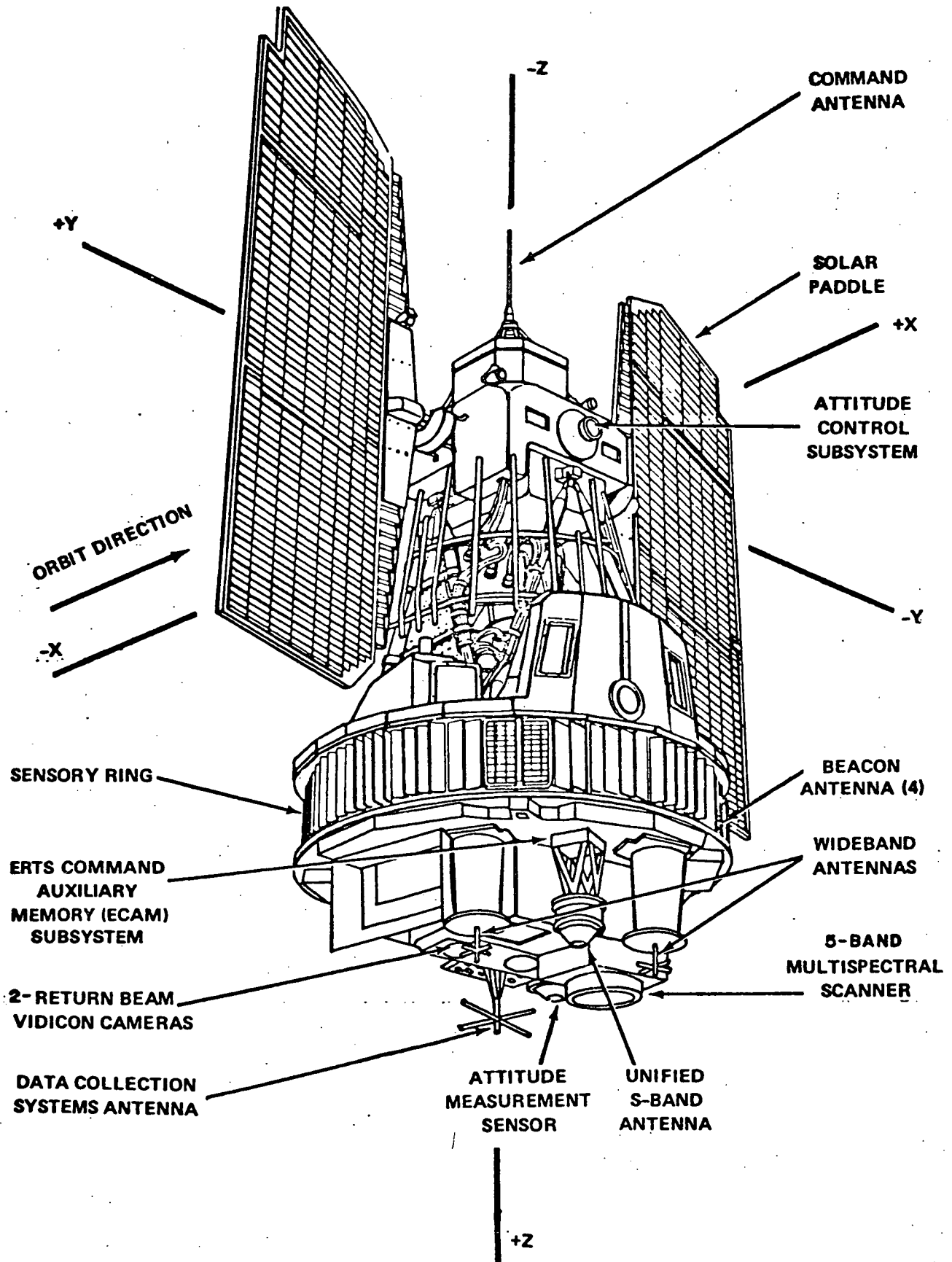
Landsat 1 was launched July 23, 1972. Landsat 2 followed it into orbit on Jan. 22, 1975. Both satellites exceeded their design lifetime of one year and returned hundreds of thousands of images covering the globe. Landsat 1 was turned off on Jan. 6 of this year. Landsat 2 is still operating at nearly full capacity.

Landsat was originally called the Earth Resources Technology Satellite (ERTS). Its name was changed in 1975 to reflect its mission more accurately.

SEQUENCE OF ORBIT EVENTS

Once in orbit, Landsat 3 will be stabilized and oriented so the onboard sensors will best view the Earth directly beneath the spacecraft. During the initial orbits, systematic turn-on and checkout of the spacecraft subsystems will be commanded from the Landsat operation control center (OCC) at Goddard Center. Simultaneously, orbital information obtained from NASA's Space Tracking and Data Network (STDN), also managed and controlled by Goddard, will be used to determine the precise orbit.

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LANDSAT-C OBSERVATORY

Next, required orbital adjustments will be determined and executed by the Landsat OCC to establish the precise orbit for the systematic ground coverage by the spacecraft's sensors. With the initial orbital correction and checkout phase complete, Landsat 3 will be commanded to begin its first year of normal operation.

Gross scheduling of the two sensors (RBV and MSS) will be performed in the operations control center for each 18-day cycle. More detailed operations will be planned for each forthcoming week, day and orbit. Real time sensor operations will be commanded over the prime observation areas of the North American continent within direct view of one of the primary Landsat data acquisition stations located at Fairbanks, Alaska; Goldstone, Calif.; and Goddard Center.

THE SENSORS

The sensor systems carried by Landsat 3 are similar but much improved over Landsats 1 and 2. These include the return beam vidicon subsystem (RBV) and the multispectral scanner subsystem (MSS). Both of these sensor subsystems view the Earth directly beneath the spacecraft.

Multispectral Scanner Subsystem

The MSS sensors operate on the principle that features on the Earth's surface can be identified in general by the energy they emit or reflect from the sun. Thus, the spectral "signature" for vegetation is different than that for rock, soil or water. In some cases, various objects within a general feature class can be distinguished one from the other by their "signatures."

Earlier MSS sensors were limited to the detection of reflected solar energy in four spectral bands. Innovations in the Landsat 3 MSS expand the capability of this system to include a fifth band for detecting emitted thermal energy. Whereas the reflected energy bands require daylight operation, the thermal band can be operated day or night.

Each MSS image covers an area measuring 185 km (115 mi.) on a side for a total area of 34,225 square km (13,225 square mi.).

The MSS gathers data by continually scanning the Earth's surface in its five spectral bands simultaneously through the same optical system.

As in the case of the Landsat 1 and 2 MSS units, four of these bands collect solar reflected energy in spectral bands ranging from 0.5 to 1.1 micrometers in wavelength (blue, green, infrared and near-infrared).

The fifth channel, new on the Landsat 3 MSS, operates in the thermal infrared region from 10.4 to 12.6 micrometers. It collects energy emitted rather than reflected by features on the Earth. The resolution of each image in this band is 237 m (778 ft.) on a side.

Return Beam Vidicon Subsystem

The Landsat 3 RBV uses two panchromatic cameras producing separate side-by-side images rather than three spectral superimposed images of the same scene as is the case with Landsat 1 and 2 RBV subsystems. Both cameras have the same broadband spectral response (green to the near infrared) of 0.505 to 0.75 micrometers.

Each RBV camera sensor on the Landsat 3 will cover an area 93 km (58 mi.) on a side with a ground resolution twice that of earlier Landsat RBV subsystems: 40 m (131 ft.) versus 80 m (262 ft.).

Each RBV camera can be operated independently of the other for either single frame or continuous coverage.

Data Collection System

The DCS carried by the Landsat 3 will collect data from up to 1,000 sensor platforms located throughout the U.S. and relay them to the Goddard Space Flight Center. Data will be relayed twice a day from each platform when the spacecraft is in simultaneous view of the continuously transmitting platform and a data acquisition station.

Each DCS platform collects data from as many as eight sensors, sampling such local environmental conditions as temperature, stream flow, snow depth and soil moisture.

LANDSAT USAGE TO DATE

Images produced by the sensors onboard Landsats 1 and 2, have been subjected to intensive study and experimentation by hundreds of scientists in a broad range of disciplines. Many of these scientists, located throughout the United States and 52 other countries, were selected by NASA for formal sponsorship as principal investigators. This was done to induce systematic examinations of Landsat's potential value as a new tool in remote sensing.

The areas studied include agriculture, rangelands, forestry, water resources, environmental and marine resources, cartography, land use, demography and geologic survey and mineral/petroleum exploration.

The volumes of scientific and technical literature on Landsat studies primarily address techniques of processing, analysis and interpretation. A limited number of quasi-operational projects also were undertaken.

Based on the research results to date, the following sections describe the current assessment of what Landsat multispectral data can be made to reveal, the extent to which these data respond to data requirements and the uses of these data.

Agriculture

Worldwide preoccupation with the food supply problem has focused strong attention on the contribution of space remote sensing to better management of agricultural systems and more timely information on output of key agricultural commodities.

Investigations of the application of satellite sensing to U.S. agriculture have dealt principally with the inventory of crop acreage, forecasting of crop yield and soil survey.

Large Area Crop Inventory Experiment (LACIE)

The Large Area Crop Inventory Experiment (LACIE) has been a major technological effort to determine how Landsat data can be used to monitor situations of major national or global importance. LACIE has been a three-year, joint experiment of USDA, NASA and NOAA to determine if foreign commodity production (wheat has been used as the example) can be forecast with an accuracy of 90 per cent, 9 years out of 10. The third crop year, 1976-1977, has been completed and a final report on the three-year period is being compiled.

So far, LACIE has shown that when field sizes are large enough to be compatible with the resolution of Landsat data the results are compatible with the 90 per cent accuracy goal and the desired confidence goal.

Since the LACIE goal is stated in production terms, both acreage and yield components must be determined. While the acreage component has been determined from Landsat data, NOAA has led the effort to determine yield by using World Meteorological Organization (WMO) weather information. The WMO data has been compared with meteorological satellite data to determine the real extent of the existing weather situation.

Better area determination is required where small fields predominate and better yield modeling is required, but the results of LACIE to date have been sufficiently promising for the USDA to want to expand the experiment to include more commodities and more crop situations.

NASA, NOAA and USDA are presently involved in a fourth year of experimentation and are planning for an increased research effort to determine how remote sensing information can help meet more broadly defined agricultural information needs.

Soil Survey -- Studies to determine whether Landsat data could provide useful soil and land system surveys also have been encouraging. Variations in soil characteristics can be identified in computer-enhanced Landsat imagery. Delineation of these patterns, confirmed by ground observation, can yield soil association maps which provide a good identification of probable soil characteristics.

Cooperative studies between soil scientists of the USDA Soil Conservation Service and scientists in universities have shown in Indiana and Missouri that digital processing of Landsat data provides sufficient information for detailed mapping of soils at scales of 1:15,840 and 1:20,000. These studies also showed that, in some cases, specific types of soils can be identified.

Spectral maps produced from Landsat data have provided important differences between soils not discernible in conventional black-and-white photographs. With a spectral map of a county prior to field sampling and measurements, a soil surveyor can determine quickly locations and a real extent of soils with significant differences. Such information can greatly reduce the number of observations and time required in the field.

Significant use of Landsat imagery is foreseen for land and soil reconnaissance level surveys in the developing world. In a project now underway in Tanzania, digitally enhanced Landsat imagery has been used with ground and aircraft observations to provide a basic land system evaluation of the Arusha district at a scale of 1:250,000.

The soil survey staff of the United Nation's Food and Agriculture Organization is now utilizing Landsat data in a world wide study of soil limitations for agricultural production.

Rangelands

Rangeland monitoring studies are conducted to gather information needed to improve productivity. They seek data on range conditions, trends, readiness for grazing and patterns of grazing use.

Investigations in the U.S. to determine the value of remote sensing from satellites for rangeland management have focused on three concerns: inventories of range vegetation types, evaluation of range feed and monitoring of rangeland improvement and change.

Landsat has produced useful rangeland inventory data in the U.S. despite the fact that not all range types show up clearly to the satellite's sensors. Low plant density, variable plant composition and the low percentage of ground cover all pose problems for remote sensors.

Dynamic sensing from Landsat of the annual grasses which cover most of the foothill terrain in California has traced the greening of the landscape with the onset of the rainy season each fall and winter and the progressive browning with the onset of the dry season in the spring and summer. Such information may help recognize potential fire hazard, project the anticipated weight gain of livestock and determine the extent to which drought and grazing have reduced available forage.

In one study, rangeland features such as meadows, springs, moist sites, islands of browse, ponded water and small reservoirs - as small as 1-1/2 acres in size--were detected by using Landsat data and manual analysis techniques. These features in rangeland environments are sensitive "areas" that need to be monitored in order to permit assessment of associated grazing, wildlife and recreational potential of the broader area.

Beside identifying existing or potential rangeland areas that require more detailed aerial or ground observation, a system of rangeland monitoring from space can help to guide a number of important decisions in developing countries:

- Timing of turnout and removal of livestock in grazing areas;
- Preparation of plans to prevent overgrazing and to open up new areas for grazing;
- Timely measures to reduce fire hazards;
- Additional investment in range improvements by draining, irrigating, seeding or fertilizing.

A study in the Arusha region of Tanzania employed Landsat data successfully in delineating boundaries for 550 distinct landscape units in an area measuring 82,000 square km (32,000 square mi.) on the basis of landform and vegetation characteristics. Fourteen grassland types of varying suitability for forage were recognized in the Landsat data. These delineations, fortified with detailed sampling information provided by aerial photography and on-site inspections, have identified promising areas for range, agricultural and ground water development.

Forestry

The research findings of various investigators indicate that Landsat data could contribute to forest management and help to reduce forest inventory costs. The data have proved useful with respect to:

- Sampling procedures for estimating volume of timber;
- Monitoring of forest cutting of clear-cut-type;
- Mapping of forest fire burns, especially the "crown fire" type common in the western part of North America.

Quasi-operational studies in northern California found that Landsat data, with the aid of multistage sampling, were able to provide timely and cost-effective inventories of gross timber volume and an economical inventory of total timber resources, including the factors of growth rate and timber stand condition. Manual and automatic techniques of data analysis used in the same studies detected changes in the resource base over time, assisting location and area estimation of harvesting activities, post-fire mapping and fire damage assessment.

A Canadian project using Landsat imagery to map forest burns in Saskatchewan detected 42 burns across the northern part of the province. The Landsat imagery was produced far more quickly and accurately than would have been possible for photographic imagery obtained from conventional helicopter or aircraft platforms.

In most of the developing world, data on forest resources are crude and incomplete at best. There are no comprehensive systems of forest inventory by aerial photography of the type found in the United States and in other technologically advanced countries.

But data requirements may also be substantially less stringent. In such a setting, Landsat data may be of significant benefit in providing basic information on the extent and location of forest resources and the changes occurring in the woodlands.

Developing countries are increasingly aware of the need to manage their forest resources not only to meet their timber and energy needs but also to preserve the ecological balance and to prevent erosion, siltation of dams and pollution of coastal waters. Mapping of forest vegetation, estimation of timber volume and measurement of the rate of depletion -- to which satellite data can make important contributions -- are essential steps in the planning of control measures.

In Brazil, Landsat imagery has been used to monitor a program for controlled development of large areas of the Amazon forest for various purposes, especially cattle grazing. Landowners, with the help of government subsidies, are permitted to cut down trees up to a third of their land holdings. Routine and systematic use of Landsat imagery has proved to be the only economic way of enforcing the terms of the government-assistance contracts and of monitoring and controlling the volume of tree-cutting.

Water Resources

Surface Water -- Landsat data have been found to be particularly reliable in locating surface water. One multispectral channel (Band 7 on the MSS) shows the contrast between water and other surfaces on the ground so clearly that water bodies larger than 10 acres can be identified with 99 per cent accuracy. With the help of computer programs, it is now possible to compile maps showing surface water areas larger than about 6 acres for most countries of the world.

For areas lacking adequate drainage maps, Landsat in many bases can provide data on stream networks to within a few per cent of those displayed on topographic maps. In some cases Landsat alone cannot provide acceptable data, but in conjunction with topographic maps showing basin boundaries it can give relevant information on land use and vegetation for water resources management with better quality, less cost and more frequency than can be obtained from other sources.

Landsat imagery can be used to assess major watershed characteristics that affect runoff. In a 1973 experiment, significant correlations were obtained between integrated basis reflectance values from Landsat and actual watershed conditions and runoff amounts in areas of dormant vegetation and dry conditions in Oklahoma. This suggests that it would be feasible, in semiarid to arid watersheds in developing countries, to develop much needed information for runoff prediction based on data from Landsat and available meteorological satellites. Recent studies in Colombia and Venezuela have indicated the value of data from synchronous meteorological satellites for improved runoff prediction and efficient, economical siting of hydro-meteorological stations.

Many studies in the United States as well as in several other countries have demonstrated the effective use of Landsat data for delineating flood areas, at least in large drainage systems where the floods lasted long enough to be observed on an 18-day cycle operated by Landsat or where trace of their past presence can be noted. For example, flooded cropland in the Indus Basin in Pakistan was distinguished easily by the satellite data from flooded semiarid areas and arid desert.

In many parts of the world, water availability stems from snowmelt. Landsat has shown a capability of measuring snowline and extent of snow within 5 per cent of the accuracy obtained by aircraft measurement or other means. The average of snow cover, multiplied by its depth and density, represents the storage of water that may be available for water supply, hydropower generation, navigation and irrigation, or that could be released suddenly to cause floods downstream.

Landsat has been able to provide reconnaissance-level data needed for the design and operation of large-scale irrigation projects and for the design of a major impoundment structure. Studies based on Landsat data have produced significant results as input to water-demand and groundwater-flow models in Kern County, Calif. These studies of a desert region have identified crop areas to within 1 per cent of the aircraft census with acceptable levels of crop identification. Landsat data are now regularly used as an important factor in the water supply/demand assessment for that region.

Subsurface Water -- Geologic information relating to groundwater may be derived from data obtained by multi-spectral sensors.

Landsat data can offer information on surface lithology, fracture patterns and vegetation and geomorphic indicators of shallow aquifers. Such information, properly interpreted, can serve as an exploration base and strategy for groundwater prospecting. Recent studies have shown that the information is useful in siting shallow wells and thus may provide a cost-effective tool for improving groundwater exploration in semiarid lands. Landsat imagery has led to the identification of alluvial fans which may contain very large groundwater reservoirs. An alluvial fan about half as big as the state of Iowa has been identified in Landsat images of western Brazil.

Two series of Landsat images taken five weeks apart made an important contribution to a multi-state study of the annual flooding of the Lower Magdalena-Cauca River Basin in northern Colombia. The sequential images made possible a classification of the river marginal lakes according to their role in tempering the water wave and their potential for serving as reservoir basins. The Landsat imagery was particularly successful in identifying the lakes that dried up in the five-week interval. The Landsat data, together with aerial photographs and side-looking airborne radar (SLAR) images, yielded information needed by the governmental planners to determine the most practical means to reclaim land in the lower part of the inundated area.

Environmental Marine Resources

The Landsat has proven of value in recognizing discontinuities of coloration in water and to distinguish differences in land cover over large areas for identifying certain types of pollution or environmental degradation. Coloration differences seen in Landsat imagery have led to detection of oil slicks and oil seepage in coastal areas, effluents carrying industrial or municipal wastes and water currents causing siltation. The effects of tin mining in shallow water along the coasts of Malaysia have been mapped with the help of Landsat data, which are also being used in a United Nations study of the environmental effects on land of strip mining of tin in that country.

Landsat imagery is being used experimentally to monitor strip-mined areas in the Appalachian region and in Idaho, to observe land deterioration in arid areas such as the Sahel and to measure the extent of damage of forest fires and floods.

In studies of sand seas, scientists have relied heavily on Landsat data to establish a basis for classifying and monitoring environmental changes in the principal desert areas of the globe.

Landsat imagery is increasingly employed in analyses of coastal areas, especially where effluents and shallow waters differ in color or reflectance from the local waters and are, therefore, readily identified and delimited. This information is applicable to problems of environmental protection, navigation and fisheries. Oil spills and seeps, illegal dumping and polluting effluents have been observed, both in shallow water and in adjoining wetlands. Certain fish stocks may also be located by identifying their habitats on the imagery. Navigation channels and inlets can be watched for changes in depths that may endanger shipping and boating. Repetitive coverage in coastal areas may be useful in determining major changes in rates of pollution, desimentation, erosion, marsh drying or subsidence.

In Gambia, Landsat imagery showed clearly that the currents from the Gambia River, carrying effluents from the city of Banjul, for some portion of the year swing past the beach frontage for which a tourist development project was planned with financing from the World Bank. New planning studies have had to take this factor into account.

Landsat also disclosed offshore pollution problems at two coastal tourist development sites in Turkey.

Cartography

The Landsat multispectral scanner has shown capabilities for cartographic mapping greatly exceeding original expectations. MSS imagery has several characteristics that enable it to contribute significantly to small-scale cartography in the United States and to become probably the most efficient current means of portraying the face of the land. These characteristics include:

- Uniformity of view over a wide area;
- Near vertical angle;
- Geometric and radiometric fidelity;
- Superior definition of certain natural features;

Capacity to be turned into a finished map product very near to the "real time" of the acquisition of the data.

Landsat imagery is helping to correct and update certain features of existing U.S. maps at scales of 1:250,000 or smaller at, or near, national map accuracy standards. With multispectral imagery it is possible to make 1:250,000 photo map overprints to fit with previous black-line data of conventional maps. The fresh information in the overprint has made it possible to observe such developments as urban sprawl and modifications to transportation networks. Using Landsat imagery and new mosaicing techniques, the U.S. Geological Survey has produced a new map of Florida which is the first color mosaic in map form that maintains uniformly high image quality.

A new type of small-scale map has been made possible by the unique capacity of Landsat Band 7 to delineate land-water boundaries. This band can define water bodies as small as 200 m (656 ft.) in diameter with high reliability and can identify streams 20 to 50 m (65 to 165 ft.) wide if they are not over-hung by trees. The capability is especially important for updating charts of estuaries in coastal areas and for outlining interior lakes.

Sensors on current Landsats are able to penetrate clear water surfaces to a depth of about 20 m (65 ft.). In the Caribbean, Landsat data made possible the charting of shallow underwater features that were previously unknown.

Cartographers have found that the Landsat scanners can produce with virtually no distortion, a generally continuous image on a defined map projection. Thus the Landsat series, with their uniform repetitive coverage, may provide the basis for an "automated" image-mapping system of the entire Earth.

For developing countries, the value of Landsat for cartographic purposes promises to be very high. More than half the geographic areas of Asia, Africa, and Latin America have not yet been mapped at scales larger than 1:1,000,000 and many of the base maps for the other areas are outdated.

With Landsat data, uncharted areas can now be quickly and cheaply mapped, existing maps can be updated with acceptable accuracy and decisions can easily be made regarding areas where higher resolution imagery from aircraft is required. Several South American countries are currently using Landsat imagery to revise their small-scale and intermediate-scale maps.

Bolivia, with sizeable parts of its territory still inadequately mapped, is now using Landsat imagery to help fill the gap. A map at the scale of 1:1,000,000 of the entire country has already been updated and published. A more detailed map at 1:500,000 of the Coipasa area, meeting U.S. National Map Accuracy Standards, has also been published. Landsat data made possible the first geomorphological map of the country and contributed corrections to a recently published tectonic map. Maps now being produced at a scale of 1:250,000 will serve as a basis for an inventory of Bolivia's natural resources including soil, forests and promising areas for mineral and petroleum exploration. With Landsat data, a task that was expected to take eight years, will now be accomplished in two.

Developing countries also have need for frequent updating of charts with respect to geographic features subject to change. For example, the temporal and spectral characteristics of Landsat are of exceptional value in defining land-water boundaries in countries with large deltas (Egypt, Bangladesh, Iran) or with shallow, interior drainage basin lakes (Iran).

Land Use

Landsat imagery has proven useful for regional planning purposes and the monitoring of land conversion along the urban fringe. However, urban planners, concerned with the disposition and relationships of small spatial units characteristic of the cityspace, generally require very high resolution imagery of the sort obtainable at present only from aerial photography.

State and regional planners, on the other hand, are interested in frequent updating of broader scale changes in the nature of land cover -- such as the extent to which agricultural land is giving way to housing or the pace at which forest land is being depleted.

The level of accuracy obtained in the United States from Landsat in distinguishing among major categories such as forests, water and urban areas has been generally an adequate 90 per cent or better. Except for urban and built-up areas, more detailed categories (which distinguish, for example, between deciduous and evergreen trees) have been generally identified at an accuracy of 80 to 85 per cent. In some studies, imagery taken at different seasons has been digitally merged and has led to greater accuracy in identification.

For present land use purposes, satellite data can be a useful complement to photographic studies from aircraft platforms. For regional planning in particular, a satellite "scene" can serve as a reconnaissance base on which planners can pinpoint areas of stress or of rapid change for which more detailed information is required and can be obtained by aerial photography.

It is anticipated that Earth resource satellites will play an expanding role in providing periodic updates to data bases originally derived from standard mapping techniques. For the first time planners have a land use data acquisition system which can be continually revised at a level of accuracy commensurate with the accuracy of statistical updates developed for population and economic data between the decennial censuses. The computer processing of Landsat tapes permits incorporation of such data in data banks, whose use is rapidly increasing, and in which social, economic and resource information from a variety of sources is retrievable in relation to specific localities.

Resource planners in several state governments in the United States are beginning to use Landsat data in large-area transportation, recreation and environmental planning.

A substantial volume of land-use information was obtained from a comparative analysis of two sets of Landsat scenes covering the state of Orissa in India. One set was taken during the dry season and the other was recorded at the end of the monsoon.

The two sets of scenes highlighted the differences between dry and wet season agricultural patterns and were used to identify promising areas for conversion to irrigated two-crop production.

These Landsat data also indicated areas suitable for dams or barrages, showed the extent of forest cutting in the highlands and coastal regions and provided a new base for checking the accuracy of crop acreage estimates done by conventional means. They further showed the changing course of the Mahandi River and its tributaries from the time of the last topographic mapping two or three decades earlier as well as major changes in sandbars and coastal islands.

Demography

In the United States, demographic applications of Landsat data have been studied under the general heading of land use investigations. To the extent that urban classification categories can be identified, a population density can be assigned to each category on the basis of careful ground sampling. The U.S. Bureau of the Census is working with digital data from Landsats to test the validity of this application. Present Landsat data are useful for identifying new urban areas and drawing urban/rural boundaries. It is generally assumed that better spatial resolution will be needed for reliable classification of urban categories.

In many developing countries, the problem in demographic census is not only to gauge increments to urban growth but to determine the number, location and population density of old and new villages. Since most village settlements cover more than one acre (the approximate size of the individual pixel that registers on a Landsat sensor up to now), satellite data may provide a better base for estimating rural population in countries where compact villages are common than any enumerating system thus far employed. In countries in which rural population is more dispersed, Landsat data can provide information on patterns of land use from which it may be possible to infer population density with some accuracy. Studies to develop appropriate sampling techniques have been undertaken in several countries in Asia and Africa. Preliminary results appear to be promising.

In studies financed by Agency for International Development in Bolivia and Kenya, the U.S. Census Bureau is seeking to determine in what ways Landsat imagery may be applied in demographic census and sample survey operations and in population estimates based on village measurements and land use interpretations. The study in Bolivia was in progress before, during and after a nationwide census undertaken by the national government. The timely coincidence of the study and the census makes it possible to test the value of Landsat data for pre-census preparatory work and postcensus checking for accuracy.

Geologic Survey and Mineral and Petroleum Exploration

One of the most valuable attributes of satellite data for geologic application derives simply from the area covered by a single observation or photograph. A few Landsat frames can cover whole mountain ranges. It requires about 500 frames to cover the U.S. continent. As a result Landsat images provide a view of the geologic fabric of continents which is compatible with the scale of modern theories of global or plate tectonics. Structural elements, perhaps irregular or even discontinuous within the confines of a smaller area, may be revealed as lineaments of regional or even semi-continental extent, and prominent rock units may be traceable far beyond the site of initial recognition. Geologists can follow such features across an entire fold belt without trying to piece together a multitude of photographs which differ in scale, exposure, light angle and quality of print.

Observations from space have two practical applications: improved geologic mapping and more efficient resource exploration. Good geologic maps are essential for the proper siting of major construction projects including railroads, highways, dams and power plants. Even in the United States, satellite data have been able to contribute to the accuracy and completeness of existing geologic maps and to identify faults hitherto unperceived.

A contribution of the U.S. Geological Survey to the 35-nation Circum-Pacific Map Project demonstrated the value of Landsat data for evaluating the accuracy of existing geologic maps and for augmenting map detail.

In some developing countries, national or regional geologic maps have been produced with the help of Landsat imagery far more quickly and efficiently than could have been accomplished by usual means and now provide a good basis for locational planning of development projects.

For site location decisions, however, satellite data on the geology, topography and hydrology of a region must be complemented by more detailed data obtained by conventional methods -- aerial photography and ground observation studies.

Landsat has made it possible, for instance, to obtain synoptic and virtually distortion free images of high-relief mountain provinces in the Himalayas, the Alps and the Andean Cordillera. Such images help increase understanding of mineral genesis.

Location of major geologic elements generally will serve as a guide to selection of smaller targets worthy of closer study as possible resource areas, particularly if the interpretation is done by a trained observer familiar with the region. These smaller target areas can be further limited by image enhancement and/or computer analysis of multispectral data, with consequent reduction in the amount of costly and time consuming ground search. Further sophistication can be added by use of data acquired during different times of the year, to take advantage of details revealed by seasonal differences in vegetation or soil moisture. In general, however, a large percentage of the potential information on static phenomena can be obtained from a single, cloud-free pass over the area.

By eliminating areas where further effort in mineral exploration is likely to be unrewarding, satellite data can identify the areas where more detailed study by aircraft and field work might be profitable. Several findings of minerals in various parts of the world have been facilitated by analysis of Landsat scenes.

On the basis of a rock-type classification map produced by digital computer processing of Landsat data, 30 prospect-target sites were chosen in a Pakistan area near known copper deposits. Out of the 19 sites visited, five yielded evidence of surface mineralization, indicating the possibility of an enriched zone of copper at depth.

A plan to make a new geological map of Egypt at a scale of 1:1,000,000 in 10 years at a cost of \$2.4 million using black-and-white aerial photographs was altered when Landsat imagery proved to be more satisfactory. The latter offered roughly three times more geological detail and could accomplish the task more quickly at less cost. In three years, maps covering about half the country have been completed and the task is expected to be finished in two more years.

A second area of applications for Landsat data relates to dynamic phenomena. The particular value of space-based measurement lies in repetitive observation which makes possible the detection of short-period changes, such as those in a stream course following a major flood, or along a coastline after a major storm. Landsat images, for example, have enabled Bangladesh scientists to identify and measure the accretion of new land to islands in the Bay of Bengal, opening the way for a government program to plant trees and stabilize the new land for agricultural purposes. Studies in Iceland showed that with the aid of Landsat some of the surface effects of intense geothermal or volcanic activity can be mapped.

GROUND SYSTEM SUPPORT

Ground control of Landsat 3 will be maintained from NASA's Goddard Space Flight Center, Greenbelt, Md. As in the case of earlier Landsats, data will be collected and processed initially at Goddard Center and at foreign ground receiving stations before dissemination to users.

Improvements in the NASA Image Processing Facility (IPF) at Goddard Center should reduce by half the time required for Landsat data processing -- from about a month to two weeks. Users will receive the data in high density computer tapes from which film or computer compatible tape products can be made quickly. In addition, the geometric accuracy of Landsat images will be significantly improved with the new processing system. Landsat 3 imagery, for instance, should achieve an accuracy of 40 meters relative to an accurate map location.

NASA Image Processing Facility

Initial processing of the data from Landsat 3 MSS and RBV sensors will be done by the NASA Image Processing Facility (IPF), the processing center for data from all of NASA's environmental and meteorological research spacecraft. The IPF is located at the Goddard Center.

Expected to be fully operational by mid-1978, this facility will be used to provide radiometric and geometric corrections for the Landsat data. Whereas the earlier archival medium for Landsat data was 70 millimeter film, high density tapes (HDT) will now be used. All film and computer compatible tape (CCT) products will be made from the HDT on file. Turn around time for the CCT product is expected to be no more than 48 hours.

Copies of the archival tapes will be sent to such user agencies as the Interior Department's EROS Data Center in Sioux Falls, S.D., 57198, Attention: User Services. This center is the principal public outlet for Landsat data, including images of CCTs.

DELTA LAUNCH VEHICLE

Landsat 3 will be launched by a two-stage Delta 2910 launch vehicle, managed for NASA's Office of Space Transportation Systems by Goddard Space Flight Center. The launch vehicle is Delta 139.

To date, the Delta has launched 138 payloads and has a success record of over 90 per cent.

The 35.3-m (116-ft.)-tall Delta vehicle consists of a liquid-fuel McDonnell Douglas Astronautics Co. extended-long-tank Thor booster, nine Thiokol strap-on Castor II solid-fuel rocket motors and a TRW Corp. liquid-fuel second stage engine. The diameter of the 132,180 kg (290,796 lb.) Delta vehicle is 2.44 m (8 ft.) not including the strap-on motors.

An all-inertial guidance system, consisting of an inertial sensor package and digital guidance computer, controls the vehicle and sequence of operations from liftoff to spacecraft separation. A sensor package provides vehicle attitude and acceleration information to the guidance computer, which generates vehicle steering commands to each stage. The system thus corrects trajectory deviations by comparing computed position and velocity against prestored values.

In addition the guidance computer performs the functions of timing and staging as well as issuing pre-programmed attitude rates during the coast phases.

LAUNCH SEQUENCE FOR DELTA 2910/LANDSAT C

<u>Event</u>	<u>Time</u>		<u>Altitude</u>		<u>Velocity</u>	
	<u>Hr.</u>	<u>Min.</u>	<u>Sec.</u>	<u>Stat.</u>	<u>Mi.</u>	<u>Km.</u>
Liftoff	0	0	0	0	0	000000
Six Solid Motor Burnout	0	0	38	4	6	1,137 1,830
Three Solid Motor Ignition	0	0	39	4	6	1,134 1,826
Three Solid Motor Burnout	0	1	17	14	22	1,837 2,958
Nine Solid Motor Jettison	0	1	27	16	26	1,979 3,185
Main Engine Cutoff (MECO)	0	3	47	59	96	11,249 18,104
First/Second Stage Separation	0	3	54	64	102	11,231 18,075
Second Stage Ignition	0	3	59	66	106	11,215 18,049
Fairing Jettison	0	4	33	80	129	11,596 18,663
First Cutoff Stage II (SECO I)	0	8	55	117	189	17,881 28,776
Restart Stage II	0	55	32	566	912	16,109 25,925
Second Cutoff Stage II (SECO II)	0	55	44	566	912	16,549 26,633
Achieve S/C Separation Attitude	1	12	49	570	917	16,546 26,628
Landsat 3/Stage II Separation	1	13	02	570	917	16,546 26,628
Activate Plasma Interaction Experiment on Stage II	1	13	22	570	917	16,546 26,628
Restart Stage II	1	24	42	578	930	16,532 26,606
Final Cutoff Stage II	1	24	46	578	930	16,517 26,582
Oscar-D Separation From Stage II	1	25	21	578	930	16,517 26,582

-more-

LAUNCH OPERATIONS

NASA launch operations from its West Coast facility are conducted by the Kennedy Space Center's Expendable Vehicles Directorate. This facility is located at the Western Test Range (WTR), Vandenberg Air Force, near Lompoc, Calif., approximately 201 km (125 mi.) northwest of Los Angeles and 451 km (280 mi.) south of San Francisco. Launch facilities are located on a promontory which juts into the Pacific Ocean near Point Arguello, making it possible to launch to the south to place payloads into polar orbit without overflying populated areas.

Landsat 3 will be launched aboard Delta 139 from Space Launch Complex 2 West, which has been extensively updated over the years to accept the various Delta configurations, including the powerful new version in use.

Some Kennedy Center personnel are on permanent assignment as members of the Delta West Operations Branch and Western Operations Support Office. These personnel are augmented by a larger management and technical group from the Kennedy Space Center in Florida during final preparations and the launch countdown.

Preparations for the launch of Landsat 3 began Dec. 7, 1977, with erection of the Delta 139 first stage at the launch pad. Significant milestones since that date include installation of the nine solid strap-on rocket motors around the base of the first stage, Dec. 9-13, erection of the interstage Dec. 13, and mating of the Delta second stage Dec. 19.

The Landsat 3 spacecraft arrived Feb. 1 and movement to the pad for mating with Delta 139 is scheduled for Feb. 23. The payload fairing which will protect the spacecraft on its flight through the atmosphere is scheduled for erection Feb. 28.

OSCAR-D AMATEUR RADIO SATELLITE

OSCAR-D is a communications satellite designed to operate with small stations in the amateur satellite service on a non-commercial basis. This 27-kg (60-lb.) satellite was built by radio amateurs in the U.S., Canada, West Germany and Japan. It was developed under the auspices of the Radio Amateur Satellite Corp., a non-profit organization, in cooperation with the American Radio Relay League, Inc. (See: NASA Headquarters Release No: 78-26, NASA to Launch OSCAR-D, Eighth Radio Amateur Satellite.)

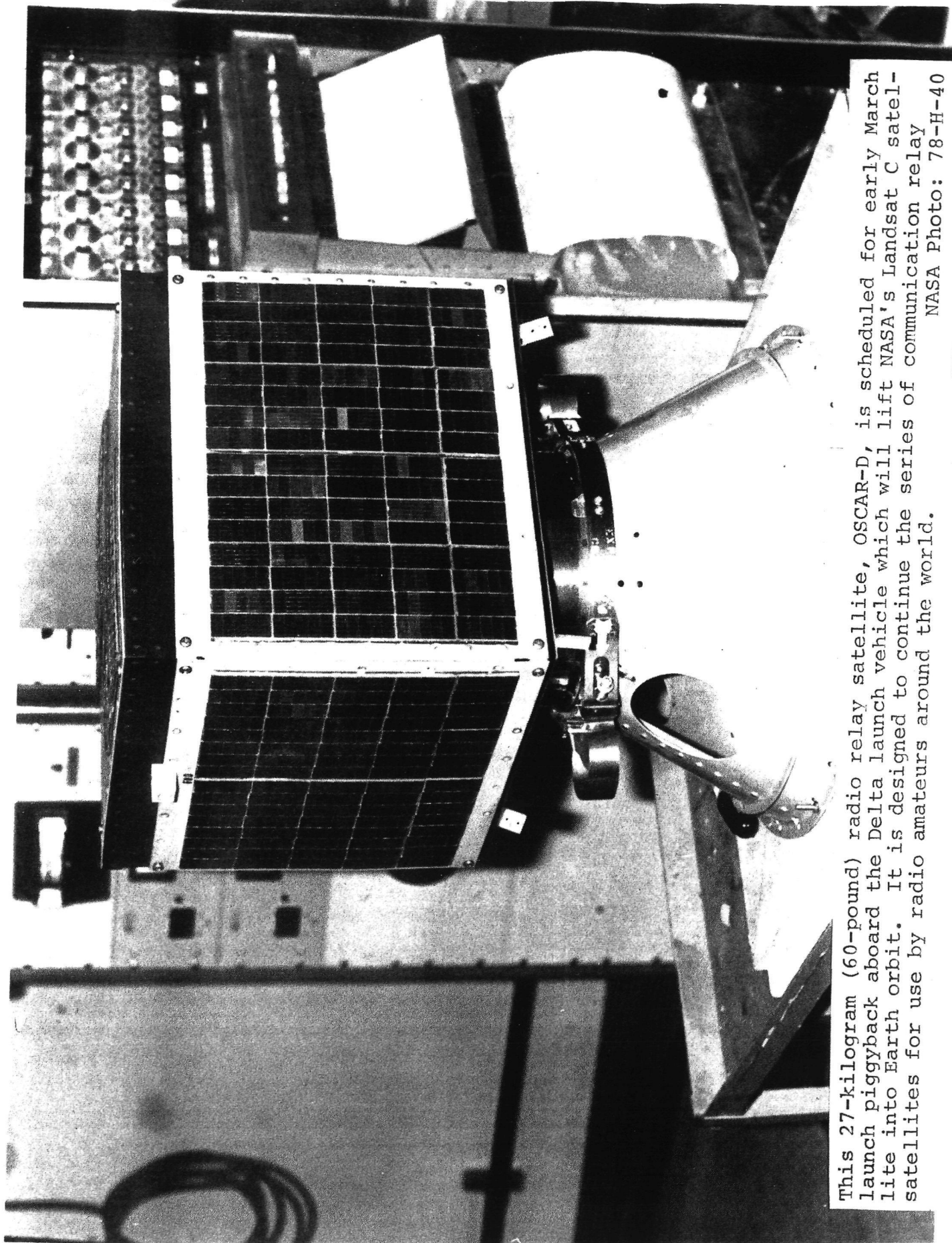
The principal objective of OSCAR-D is to expand the educational program that brings communications satellites into classrooms across the U.S. and Canada.

Additional objectives include the provision of continuous radio communications for the conduct of a wide range of experiments, particularly with small amateur ground terminals. Some of these experiments include emergency communications between medical centers and isolated areas, along with mobile communications with aeronautical, maritime and land units.

OSCAR-D, eighth in a series, will be placed into a Sun-synchronous orbit at an altitude of about 900 km (560 mi.). In this orbit, the solar-powered satellite will pass within range of any one location at about the same time each morning and evening. Anticipated useful lifetime of the satellite is three years.

OSCAR-D carries two transponders for amateur radio communications. Both of these transponders use the same uplink frequency of 145.9 MHz but employ different downlink frequencies of 29.4 MHz and 435.1 MHz. Current plans are to use only one transponder at a time.

The amateur radio satellite will be designed OSCAR 8, once it is put in orbit.



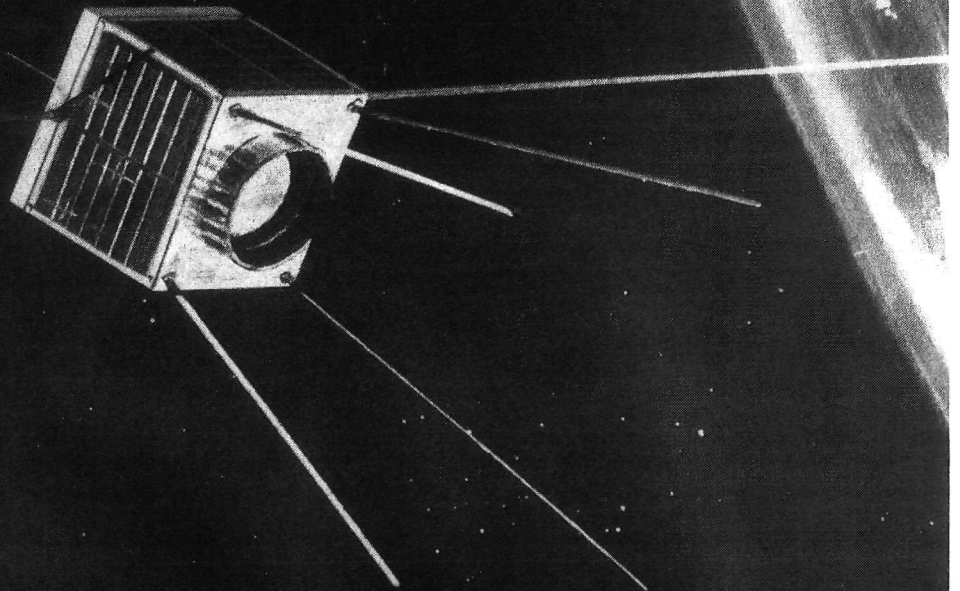
This 27-kilogram (60-pound) radio relay satellite, OSCAR-D, is scheduled for early March launch piggyback aboard the Delta launch vehicle which will lift NASA's Landsat C satellite into Earth orbit. It is designed to continue the series of communication relay satellites for use by radio amateurs around the world.

NASA Photo: 78-H-40

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This artist concept shows OSCAR-D as it would appear in Earth orbit. This radio amateurs' satellite becomes OSCAR 8 when successfully orbited. It is designed to continue the series of communications relay satellites for use by radio amateurs around the world.

NASA Photo: 78-H-39



PLASMA INTERACTION EXPERIMENT

The Plasma Interaction Experiment (PIX) is part of a broad investigation by NASA's Lewis Research Center, Cleveland, Ohio, to develop design guidelines, materials, devices and test methods for controlling detrimental interactions between high voltage systems and the space plasma environment. Systems of interest include solar arrays, power system conductors and insulators, and other exposed components. Surface plasma interactions include current drains, charge buildup on insulators and discharges to or through the space plasma.

Specific objectives of the PIX flight experiment are to measure the plasma coupling current and the negative voltage breakdown characteristics of a solar array segment and a gold plated steel disk. Measurements will be made over a range of surface voltages up to plus or minus one kilovolt.

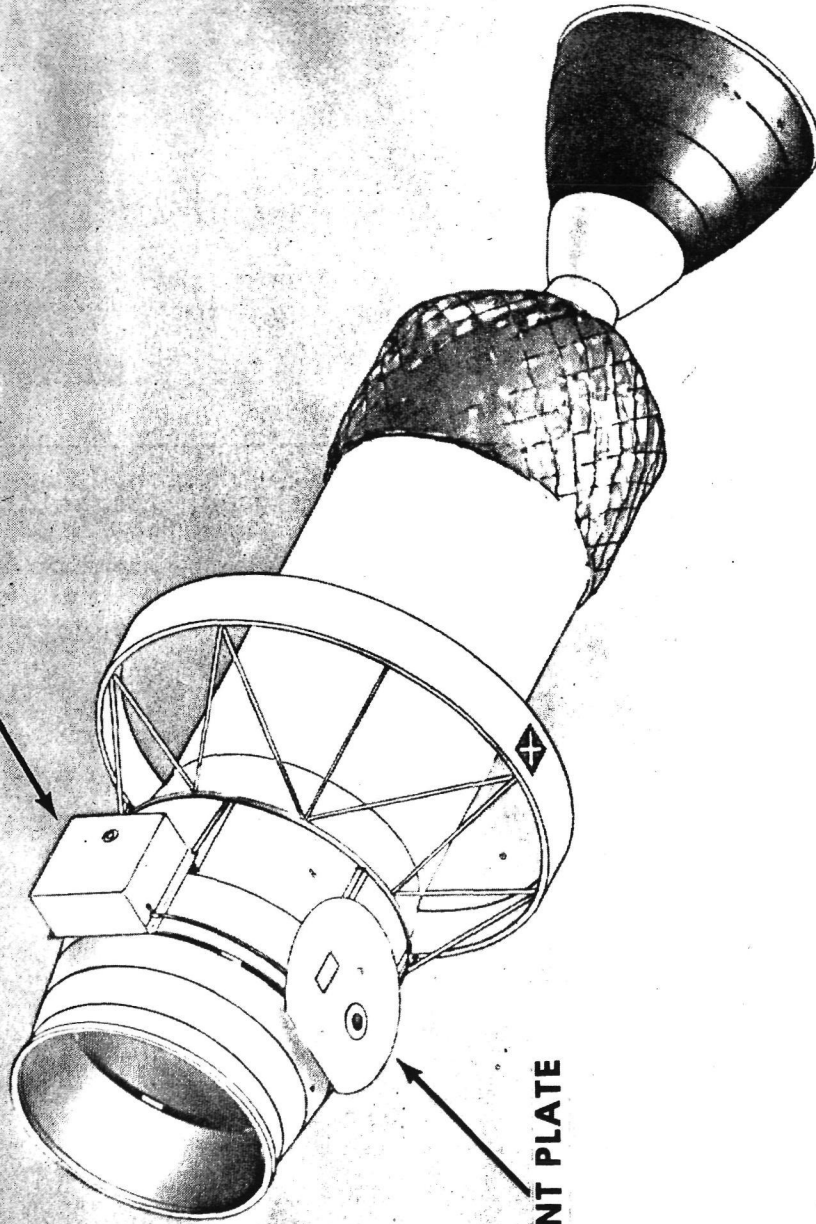
The 34-kg (75 lb.) PIX is attached to the second stage of the Delta launch vehicle which will remain in orbit at an altitude lower than either the Landsat 3 or the OSCAR 8.

LANDSAT-C/DELTA LAUNCH TEAM

NASA Headquarters

Dr. Anthony J. Calio	Associate Administrator for Space and Terrestrial Applications
Leonard Jaffe	Deputy Associate Administrator for Space and Terrestrial Applications
Pitt Thome	Director, Resources Observations Division
Harry Mannheimer	Landsat Program Manager
Joseph B. Mahon	Director, Launch Vehicle and Propulsion Program
Peter T. Eaton	Delta Program Manager

ELECTRONICS AND POWER PACKAGE



EXPERIMENT PLATE

PLASMA ENTERACTION EXPERIMENT (PIX)

Goddard Space Flight Center

Dr. Robert S. Cooper	Director
Robert E. Smylie	Deputy Director
Robert N. Lindley	Director of Projects
Ronald K. Browning	Project Manager - Landsat
Luis Gonzales	Deputy Project Manager, Technical
Ed Baden	Deputy Project Manager, Resources
Dr. Stanley C. Freden	Project Scientist
Ennio Scopel	Spacecraft Manager
Pierce Smith	Mission Operations Manager
James L. Michael	Mission Support Manager
Stephen F. O'Dea	Networks Support Manager
Robert C. Baumann	Associate Director for Space Transportation Systems
David W. Grimes	Delta Launch Vehicle Project Manager
Don V. Fordyce	Associate Director for Projects
William A. Russell	Deputy, Delta Project Manager, Technical
John Langmead	Deputy Delta Project Manager, Resources
Robert J. Goss	Mission Analysis and Inte- gration Manager, Delta Project Office

Kennedy Space Center

Lee R. Scherer	Director
Gerald D. Griffin	Deputy Director
Dr. Walter J. Kapryan	Director of Space Vehicle Operations
George F. Page	Director, Expendable Vehicles
W. C. Thacker	Chief, Delta Operations Division
R. J. Kimlinger	Chief, Delta Western Operations Branch
H. R. Van Goey	Chief, Western Operations Support Office
E. J. Langenfeld	Spacecraft Coordinator

Lewis Research Center

Dr. Bernard Lubarsky	Acting Director
Fred Haley	Plasma Interaction Experiment

CONTRACTORS

General Electric Co.
Space Division
Valley Forge, Pa.

Computer Sciences
Technicolor Assoc.
Greenbelt, Md.

Hughes Aircraft Co.
Space and Communications Group
El Segundo, Calif.

RCA
Astro Electronics
Princeton, N.J.

McDonnell Douglas
Astronautics Co.
Huntington Beach, Calif.

Prime contractor: space-
craft, ground data handling
system and spacecraft wide-
band video tape recorders.

Spacecraft operations
support

Multispectral scanner
subsystem

Return beam vidicon, power
subsystem, command receivers

Delta launch vehicle